NON-DESTRUCTIVE INSPECTION METHOD AND APPARATUS THEREFOR

Technical Field

The present invention relates to a method of

5   inspecting a deficiency, such as a crack in a metal surface,

and, more particularly, to an inspection method for

performing non-destructive inspections called penetrant

inspection and magnetic-particle inspection and an

apparatus therefor.

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Background Art

A penetrant inspection and magnetic-particle

inspection inspect a deficiency, such as a crack (crack)

having an opening in the surface of metal in a non-

15   destructive manner. In the penetrant inspection, normally,

a red liquid called penetrant is applied to the surface to

be inspected, the penetrant is wiped out after a

predetermined time passes, and white powder called a

developer is applied. If there is a deficiency, such as a

20   crack, the penetrant remaining in the crack comes to the

surface due to capillary phenomenon, indicating a

deficiency in red. In case of magnetic-particle inspection,

a solution containing fluorescent magnetic powder is

sprayed on a specimen or a magnetic substance to magnetize

25   the specimen. If there is a deficiency, such as a crack,

the magnetic flux is concentrated on the deficient portion, so that the fluorescent magnetic powder is gathered and emits green light when ultraviolet rays are irradiated, thereby showing a deficiency. Conventionally, those

5   deficiency indications are observed visually to inspect deficiencies.

Such a visual inspection has a problem on the inspection reliability, such as missing of a deficiency due to the fatigue of an inspector or that different inspection

10 results due to the difference in capability among inspectors are left merely by characters, such as "passed".

With regard to the magnetic-particle inspection, an automatic inspection apparatus has been developed for those parts which are important and are to be mass-produced. As

15 it is a special-purpose apparatus, it cannot easily inspect parts having multifarious shapes.

Further, as the penetrant inspection needs to detect surface colors as a two-dimensional distribution at high precision, even if there is a colorimeter capable of

20 accurately measuring the chromaticity at a point, two-dimensional sweeping is needed. In terms of inspection time and cost, therefore, it is difficult to easily perform automatic inspection of parts having multifarious shapes.

Furthermore, when a specimen was large, there were

25 cases where it could not tell what part of the specimen the

image that was acquired by automatic inspection was or what part of the specimen the detected deficiency was.

Moreover, if both the penetrant inspection and magnetic-particle inspection can be done automatically by a single apparatus, the economical merit would be improved significantly, but such an apparatus and technology have not yet appeared so far.

It is therefore an object of the invention to provide a deficiency inspection method, a deficiency inspection apparatus and a deficiency-inspection aiding method which overcome the above-described problems and facilitate discrimination of real deficiencies.

It is also an object of the invention to provide a deficiency inspection method, a deficiency inspection apparatus and a deficiency-inspection aiding method which can easily find the position of a deficiency even on a large specimen.

Disclosure of Invention

The invention picks up a specimen using a color video camera. If a color video camera is used directly, however, it cannot pickup an image properly in the penetrant inspection because of the irradiation-oriented regular reflection light from the specimen. In the magnetic-particle inspection, illumination light (ultraviolet rays)

causes a foreign matter on the specimen to emit blue light, making it difficult to identify a deficiency. To eliminate the regular reflection light, therefore, a polarization filter is put in both the illumination and the camera.

5 Further, a filter for cutting ultraviolet rays is placed in front of the camera.

As the color camera, a white illuminating lamp and an ultraviolet illuminating lamp are constructed as a single probe, it can be used both in the penetrant inspection and

10 magnetic-particle inspection. In the penetrant inspection, xy chromaticities on the surface of the specimen are computed from a video signal from the color video camera to detect a red deficiency-indicating portion. In the magnetic-particle inspection, detection is made after

15 differentiation is performed on a green video signal to highlight a deficiency.

To prevent overlooking and overdetection in automatic inspection, the inspection result is displayed in a color image and portions that have been determined as

20 deficiencies in the automatic inspection are encircled in rectangular shapes so that an inspector checks the rectangular portions against the original images one by one to discriminate if they are real deficiencies. The original images and the inspection results are saved as

25 recordings on a magneto-optical disk or the like.

When a specimen is like an elongated object which cannot be fitted in one field of view, the inspection position is specified by placing a scale in the pickup field of view and simultaneously picking up the scale and

5   an image to be inspected.

Brief Description of Drawings

FIG. 1 is a diagram showing one example of an inspection target which is handled in the invention.

10   FIG. 2 is a structural diagram of a deficiency inspection apparatus showing one embodiment of the invention.

FIG. 3 is a diagram showing the effects of a polarization filter in the apparatus structure in FIG. 2,

15   and FIG. 4 is a diagram showing the effects of an ultraviolet-rays cutting filter.

FIG. 5 is a flowchart illustrating the flow of an automatic inspection method in a penetrant inspection according to the invention.

20   FIG. 6 shows an xy chromaticity diagram.

FIG. 7 is a diagram showing a structure for camera calibration, and FIG. 8 is a diagram showing the flow of a camera calibration process.

FIG. 9 is a diagram illustrating a method of acquiring

25   a reference white chromaticity from a chrominance image.

FIG. 10 is a diagram for explaining a method of computing a hue on a chromaticity diagram, FIG. 11 is a diagram for explaining a method of computing a chrominance on the chromaticity diagram, FIG. 12 is a diagram

5   illustrating a method of acquiring a deficiency candidate area from the hue obtained in FIG. 10 and the chrominance obtained in FIG. 11, and FIG. 13 is a diagram illustrating a method of acquiring a deficiency area by discriminating a pseudo deficiency from the deficiency candidate area

10   obtained in FIG. 12.

FIG. 14 is a diagram for explaining a method of acquiring a threshold value 135 to acquire a deficiency area by discriminating a pseudo deficiency from the deficiency candidate area shown in FIG. 13.

15   FIG. 15 is a diagram showing an example of an image processing algorithm in the magnetic-particle inspection of the invention, and FIG. 16 is a diagram for explaining a method of discriminating a pseudo deficiency in the magnetic-particle inspection of the invention.

20   FIG. 17 is a flowchart illustrating the process of confirming a deficiency and saving data in the invention.

FIG. 18 is a diagram exemplifying a method of generating a deficiency candidate marker according to the invention, and FIG. 19 is a diagram exemplifying a

25   deficiency candidate displaying method according to the

invention.

FIG. 20 is a diagram showing one example of a method of specifying an inspection position in the invention, and FIG. 21 is a diagram showing one example of an inspection image which contains information for specifying the inspection position in the invention.

FIG. 22 is a diagram showing one example of the structure of inspection result data to be stored in a memory device 7.

Best Mode for Carrying Out the Invention

A preferred embodiment of the invention will now be described with reference to the accompanying drawings.

FIG. 1 shows one example of a deficiency which is inspected in the invention.

FIG. 1A shows one example of a penetrant inspection image, a white penetrant is applied to a specimen 1, a deficiency 2 (high contrast) and pseudo deficiencies 3 (low contrast) are observed. In the penetrant inspection, the deficiency 2 is highlighted as a red indicated pattern. The pseudo deficiencies appear when the penetrant stays in surface-polishing originated lines or the like and cannot be wiped out clean, and becomes a light red indicated pattern.

FIG. 1B shows one example of a magnetic-particle

inspection image, and it is assumed that a deficiency 2 exists on a specimen and fluorescent magnetic powder has already been applied and magnetized. When ultraviolet rays are illuminated on it, the fluorescent magnetic powder that

5 has gathered on the deficiency 2 due to magnetization emits green light. If there is a welded portion in the specimen 1, for example, the fluorescent magnetic powder is gathered along welding beads so that green pseudo deficiencies 3 appear in some cases.

10 FIG. 2 is a structural diagram of a deficiency inspection apparatus according to the invention. There are a deficiency 2 and pseudo deficiencies 3 on a specimen 1. They are picked up by a color video camera 21. A white illuminating lamp 24a is turned on in inspecting a

15 penetrant inspection image, whereas an ultraviolet illuminating lamp 24b is turned on in the magnetic-particle test. The white illuminating lamp 24a is connected to a white-illuminating-lamp connector 25a and is connected to an illumination power supply 8 by an illumination cable 26.

20 In the magnetic-particle inspection, the illumination cable 26 is connected to an ultraviolet-illuminating-lamp connector 25b. To avoid the influence of outside light, a hood 27 is attached. Although the illuminating lamp in use has a ring shape in FIG. 2, a single rod-shaped lamp or

25 plural rod-shaped lamps may be used.

A color video signal from the color video camera 21 includes a type in which R, G and B are separated and a composite video signal. Either signal is stored as image data for R, G and B in a color image memory 4. The color

5   image data is analyzed by a computer 5 and the results of deficiency detection are shown on a color monitor 6.

The deficiency inspection results are saved in a data memory device 7. Further, an image displayed on the color monitor 6 can be printed out from an unillustrated printer

10 as needed.

A polarization filter 22a and an ultraviolet-rays cutting filter 22b are placed in front of the lens of the color video camera 21. A polarization filter plate 23 is provided under the white illuminating lamp 24a. The

15 polarization filter 22a and the polarization filter plate 23 serve to prevent reflection of the illumination or regular reflection light from the specimen 1 in the inspection of the penetrant inspection image. While the output video image of the color video camera 21 is watched,

20 the polarization filter 22a is turned and is fixed to the place where there is least image reflection or light reflection. The adjustment of the polarization filter 22a may be done automatically based on the video output signal of the color video camera 21.

25 The ultraviolet-rays cutting filter 22b serves to

inhibit unnecessary light emission from an adhered foreign matter caused by the ultraviolet illuminating lamp 24b.

FIG. 3 is a diagram showing the effects of the polarization filter 22a and the polarization filter plate 23.

FIG. 3A shows a state where there are no filters, and FIG. 3B shows a state where the filters are attached and the rotational angles of the filters are adjusted. In FIG. 3A, there is an illumination reflection 30, making deficiency detection difficult. The ring-like illumination reflection is on the assumption of a case where the white illuminating lamp 24a is ring-like. In FIG. 3B, this illumination reflection is gone.

FIG. 4 is a diagram showing the effects of the ultraviolet-rays cutting filter 22b. FIG. 4A shows a state where there are no filters, and FIG. 4B shows a state where the filters are attached. In FIG. 4A, light emission from a foreign matter 40, such as a little piece of thread, and regular reflection light 41 from the specimen are picked up by the color video camera 21, making deficiency detection difficult. In FIG. 4B, those noises are cut and the image shows only light emission by the fluorescent magnetic powder as in a case where the specimen 1 is visually observed by a man.

To begin with, a method of detecting a crack

deficiency in a penetrant inspection image will be explained with reference to FIGS. 5 through 13. FIG. 5 illustrates a method of automatically detecting the deficiency 2 in the penetrant inspection.

First, image pickup 50 of the specimen 1 on which a developer is applied is executed using the white illuminating lamp 24a. Next, chromaticity conversion 51 to acquire xy chromaticity values of individual pixels from acquired R, G and B color image data is executed.

Next, determination 52 of reference white to compute the reference white chromaticity of the developer is performed and computation 53 of the hue and chrominance at each position on the image with respect to the reference white is carried out.

Then, a region whose hue and chrominance lie within a specific range is extracted by binarization in order to execute extraction 54 of deficiency candidates.

A real deficiency 2 has a clear contour portion, and a pseudo deficiency often has an unclear contour portion. In this respect, differentiation 55 of the chrominance image is performed and the ratio of a change in chrominance of the contour portion of the extracted deficiency candidate area is obtained. Next, shape measuring 56 for the area, the aspect ratio, the length and so forth of the deficiency candidate area is performed. Then, a region whose ratio of

a change in chrominance and whose length and area are larger than specified ones is detected as the real deficiency 2 in detection 57 of deficiency. Further, the inspection results are displayed on the color monitor 6 and

5   a deficiency is confirmed by an inspector, after which image data, shape data, positional information, etc. are saved in the data memory device 7 or printed out to be saved as a hardcopy 58.

In color-based inspection, it is necessary to evaluate colors quantitatively. In the step of chrominance

10   conversion 51, therefore, RGB data of the picked-up color image is converted to chromaticities x, y and luminance Y that are specified by CIE (Commission internationale de l'.clairage), and inspection is carried out using them.

15   Expression of chromaticities x, y in two-dimensional orthogonal coordinates is called a chromaticity diagram shown in FIG. 6. In the chromaticity diagram, individual colors are arranged around white and become clearer as they are located farther away from white. Hereinafter, the tone

20   is called a hue, the clearness of each color is called a chromaticness and the distance between two chromaticities on the chromaticity diagram is called a chrominance. FIG. 6 shows a chromaticity range of a penetrant inspection image.

25   In this method, color calibration is executed

beforehand using a camera calibration color card 71 as shown in FIG. 7 in order to perform high-precision conversion of RGB data to chromaticities x, y and luminance Y. The flow of that process is shown in FIG. 8. The

5 camera calibration color card 71 has three or more colors painted. The colors are picked up by the color video camera 21 (81), and the RGB values of the individual colors are computed (82). The chromaticities x, y and luminance Y are measured (83) by a colorimeter 72. The relationship

10 between the RGB values and xyY values is expressed by equations (1) and equation (2).

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} R \\ B \\ G \end{pmatrix} \qquad \cdots (1)$$

15 where X, Y and Z are called three stimulus values.

chromaticity: $x = \dfrac{X}{X+Y+Z}$ $y = \dfrac{Y}{X+Y+Z}$ luminance: Y $\cdots$ (2)

The xyY values are computed by substituting the RGB

20 values of the RGB values of the individual colors acquired from the camera into the equations (1) and (2) and conversion parameters specific to the camera are obtained

by acquiring a_{11} to a_{33} which make the values coincide with the xyY values measured by the colorimeter. As there are nine unknown parameters, the parameters can be computed from the RGB values (R_1, G_1, B_1) to (R_3, G_3, B_3) of at least three colors and their corresponding xyz values (x_1, y_1, Y_1) to (x_3, y_3, Y_3) from the colorimeter.

As it is apparent from the equation (2) that XYZ can be computed from the xyY values from the following equation (3),

$$X = Y \times x/y, \quad Y = Y, \quad Z = Y \times (1-x-y)/y \quad (3)$$

XYZ are acquired by substituting the xyY values of the three colors from the colorimeter into the equation (3) and are substituted into the equation (1).

$$\begin{pmatrix} X_i \\ Y_i \\ Z_i \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} R_i \\ G_i \\ B_i \end{pmatrix} \qquad (i = 1, 2, 3) \cdots (4)$$

Accordingly, it is possible to acquire conversion parameters a_{11} to a_{33} specific to the camera (84) and acquire, from the RGB values from the camera, the xyY values that are equal to the values from the colorimeter.

Using the conversion parameters specific to the camera

that have been computed beforehand by calibration, the RGB

values acquired from the camera are subjected to

chromaticity conversion to xyY values and a chromaticity

distribution in the image is computed, after which the

5   chromaticity value of the developer or the chromaticity of

a non-deficient portion in the image is computed as a

reference value in 52. First, the chromaticities x, y of

each pixel in the image are checked and the number of

pixels that take x, y values as given in a graph in FIG. 9A

10   is counted to prepare the two-dimensional chromaticity

distribution of the chromaticities. Then, the x

chromaticity value (FIG. 9B) and the y chromaticity value

(FIG. 9C) for which there are the largest number of pixels

in the image are acquired. As most of the image is a non-

deficient portion, the x, y chromaticity values at the peak

15   values in the two-dimensional chromaticity distribution

become xy chromaticity values of the reference white.

In 53, the hue and chrominance at each position on the

image with respect to the reference white are computed.

20   Given that the chromaticity of the reference white is (x_c,

y_c) and the chromaticity at the position (i, j) on the

image is (x_{ij}, y_{ij}), the hue at the position (i, j) is

computed in the direction toward the reference color on the

chromaticity diagram as shown in FIG. 10. The computation

25   equation is given in an equation (5).

hue: $\theta_{ij} = \left(\dfrac{y_{ij} - y_c}{x_{ij} - x_c} \right)$ $\cdots$ (5)

Further, the chrominance at the position (i, j) is computed in terms of a distance from the reference color on the chromaticity diagram as shown in FIG. 11. The computation equation is given in an equation (6).

chrominance: $d_{ij} = \sqrt{(x_{ij} - x_c)^2 + (y_{ij} - y_c)^2}$ $\cdots$ (6)

From the hue and chrominance at each position of the image with respect to the reference white computed in the above-described manner, the range that is wanted to be detected as a deficiency is limited by the hue (in the diagram, the range of the hue θ is $\theta_1 \leqq \theta \leqq \theta_2$), and the degree of a difference in clearness of the color and the reference white is limited by the chrominance (in the diagram, the range of the chrominance d is $d_1 \leqq d \leqq d_2$). And, portions which lie within this range are extracted as deficiency candidate areas.

Some of the deficiency candidates that have been acquired through the limitation with the hue and chrominance may not be needed to be detected as deficiencies. For example, a portion whose chromaticity

gradually changes with respect to the reference white is
not a deficiency, but an area which has a clear contour is
a deficiency. Therefore, a portion whose color changes
gently with respect to the ambient colors is considered as

5   a normal portion or pseudo deficiency 3, and a portion
whose color changes sharply is considered as a deficiency 2.
In (55), the amounts of a change in chrominance with
respect to the reference white are acquired for deficiency
candidate areas and only the area whose value is equal to

10   or greater than a given value is considered as a deficiency.

A description will be given with reference to FIG. 13.
FIG. 13A shows deficiency candidate areas 131 extracted in
54.   133 in FIG. 13B is a graph of chrominance with respect
to the reference white on 132 in FIG. 13A. Further, the

15   amount of a change in the chrominance 133 at each position
on 132 or differentiation of 133 is a chrominance
differentiation distribution 134 in FIG. 13D. Apparently,
an area which has a small amount of a change in chrominance
with respect to the reference white has a small

20   differential value. As indicated in (d), an area whose
differential value is larger than a given value 135 is
considered as a deficiency area. As a result, only a
deficiency area 136 which has a large chrominance and has a
large amount of a change in chrominance or has a clear

25   contour as in FIG. 13C is detected.

A method of determining the threshold value 135 will
now be discussed with reference to FIG. 14. In a graph in
FIG. 14A, the vertical axis is the maximum value in the
chrominances in each deficiency candidate area extracted by
5   the hue and chrominance, the horizontal axis is the maximum
value in the differential values of the chrominance at the
contour portion of each deficiency candidate area, and the
values for the real deficiency 2 are plotted by X and the
values for the pseudo deficiency 3 are plotted by O. 141a
10   is a degree distribution of the individual chrominance
differential values and 142a is a degree distribution of
the chrominance values. When a deficiency is clearly
distinguished from a pseudo deficiency, a decision line
144a should be a straight line 144a that passes the bottom
15   peaks in the degree distributions 141a and 142a and is
perpendicular to a main axis 143a of inertia at the plotted
points. When a deficiency is not distinguished from a
pseudo deficiency, a decision line should be 144b as shown
in FIG.14B. That is, all deficiency candidate areas are
20   detected as deficiencies to avoid any overlooking and
missing.

A deficiency detection method in the magnetic-particle
inspection will now be described using FIGS. 15 and 16.

FIG. 15 shows an example of an image processing
25   algorithm to analyze the contents of the data memory device

7 in the magnetic-particle inspection. Acquisition of an RGB image is performed (151), then differentiation of a G image which contains the largest amount of emission information of the fluorescent magnetic powder is performed (152). This highlights a portion, such as a crack deficiency, which has a large linear change in luminance Y, and does not highlight a portion, such as a portion where magnetic powder stays, which has a high luminance but has a small change in luminance.

Next, a threshold value for binarization is determined from the average value of the G differential image and binarization is performed (153). An image noise, such as an isolated point, is removed from the binarized image (154), then deficiency candidates are acquired, after which the lengths, contrasts and so forth of those deficiency candidates are computed (155). When those values are larger than specified values, they are determined as deficiencies.

FIG. 16 shows a method of discriminating a deficiency from a pseudo deficiency. When the luminance distributions of the deficiency 2 and the pseudo deficiency 3 are taken on a line 161 as shown in FIG.16A, for example, a luminance distribution 162 as shown in FIG.16B is acquired. The luminance values of the deficiency 2 and the pseudo deficiency 3 are about the same. Differentiating the

luminance distribution 162 yields a luminance differential

distribution 163 as shown in FIG.16B. As the luminance of

the deficiency 2 changes drastically and the luminance of

the pseudo deficiency 3 changes slowly, only the deficiency

5   2 can be extracted as in FIG.16C by determining the results

of the differentiation using a decision threshold value 164

of FIG.16D.

With reference to FIG. 17, confirmation of a

deficiency and data saving will be explained. Although a

10   deficiency should have been distinguished from a pseudo

deficiency and only a deficiency should have been extracted,

visual confirmation of a deficiency is executed last in

both the penetrant inspection and the magnetic-particle

inspection in order to prevent missing or erroneous

15   determination.

FIG. 17 is a flowchart illustrating the process of

confirming a deficiency. First, a marker of a deficiency

candidate is shown on the portion which has been determined

as a deficiency in the automatic determination (171). Next,

20   the computer 5 request an inspector to determine deficiency

candidates one by one (172). The inspector determines if

it is a real deficiency while viewing the color original

image (173). When the inspector recognizes it as a real

deficiency, the position, length, contrast and so forth of

25   the deficiency are registered in the data memory device 7

(174) and the color of the marker is turned to red (175).

When the inspector determines the portion as a deficiency candidate in the confirmation of the deficiency candidate, the marker is erased (176). If there remains a deficiency candidate, the marker is given on the next deficiency candidate. When confirmation of all the deficiency candidates is completed (177), the color original image is saved in the data memory device 7 (178).

FIG. 18 exemplifies a method of generating a deficiency candidate marker. A center line 182 which connects a beginning point P1 and an end point P2 of a deficiency candidate 181 is acquired, and long sides AB and CD of a deficiency candidate marker 183 are set in parallel to and apart from the center line by a given value m. Short sides AD and BC are likewise determined. The length of the deficiency is a distance between P1 and P2. In case of the magnetic-particle inspection, the contrast that is related to the depth of the deficiency is acquired by scanning a contrast computation line 184 from P1 to P2, acquiring a difference between an average luminance and a highest luminance on this line, acquiring this difference from P1 to P2, and setting an average value of the differences as the contrast of the deficiency. The deficiency candidate marker should not necessarily be rectangular. The short sides AD and BC may be made

semicircles; the key point is that a deficiency should not be hidden by the marker.

FIG. 19 exemplifies a method of displaying a deficiency candidate on the color monitor 6. The inspector
5 is requested to confirm candidates on the original image in order from a candidate whose deficiency length is long. First, all the markers are displayed in white, the marker of the candidate which has been determined as a real deficiency is changed to another color, e.g., red, and the
10 marker of the candidate which has been determined as a pseudo deficiency is erased.

FIG. 20 shows one example of a method of specifying an inspection position when the specimen 1 is an elongated object. A scale 201 with graduations is fixed to the
15 specimen 1 and image pickup is carried out in such a way that the scale 201 comes into a part of a camera's visual field 202. The graduations of the scale may be made by writing numerals, for example, every centimeter. Further, the scale 201 for the penetrant inspection may be made
20 different in color from the scale 201 for the magnetic-particle inspection. In the magnetic-particle inspection, for example, the numerals on the scale are graduations and numerals in fluorescent green color on the white background.

FIG. 21 shows one example of a picked-up screen. The
25 scale 201 is picked up at the lower portion of the screen

at the same time, and the camera position on the specimen 1

is computed from the scale 201. That is, graduation

numerals 210 are described on the scale 201 and can be

identified by pattern matching or the like using the

5   computer 5. The scale 201 has segmentation lines 211, for

example, every centimeter, so that the finer camera

position can be computed. A cross-section signal 213 is

acquired as an image signal of an inspection line 212

between C1 and C2 on the image. From the signal, a left-

10   hand end A and a right-hand end B of the image and the

positions of 16-20 of the segmentation lines 211 are known.

The image pickup magnification can be computed from the

positions of 16-20, and the accurate position of the

deficiency 2 on the specimen 1 can be known based also on

15   the graduation numerals 210.

The above-described inspection results are stored in

the memory device 7, and an example of the storage is

illustrated in FIG. 22. When the specimen 1 has a large

surface to be inspected and the whole to-be-inspected

20   surface cannot fit in a single inspection screen, it is

segmented into several images before image pickup and

inspection are carried out. At this time, the images to be

segmented are set in such a way that the pickup ranges on

the inspection surface overlap one another a little. 221a,

25   221b and 221c indicate image segments of the specimen 1.

Inspection is performed on each image segment. The results or the entire image information for each specimen is stored together and information of each deficiency, such as the position, length, area, chromaticity and hue, is also

5 stored as shown in 222.

The inspector first displays the data 222 for each specimen stored in the memory device 7 on the screen of the monitor 6 and checks it. When the inspector wants to see the details of the portion where a deficiency exists, he

10 calls a corresponding image segment from the name of the specimen and the image No. and displays it on the screen of the monitor 6. At this time, information, such as the position, length, area, chromaticity and hue of a deficiency, which is stored in association with the

15 displayed image data can also be displayed on the screen of the monitor 6.

Highlighting the detected deficiency candidate on the screen using a marker or the like can prevent overlooking of a deficiency, on the screen, which is larger than 0.1 to

20 0.3 mm of the same degree as that in the visual inspection done conventionally.

Further, increasing the image detection magnification can permit a deficiency smaller than a visible one to be detected. Displaying a deficiency smaller than a visible

25 one on the screen in magnified manner can allow the

position, length, area, chromaticity, hue, etc. of even a deficiency smaller than a visible one to be confirmed on the screen.

As an image is input using a color video camera according to the invention and ultraviolet rays reflected from a specimen can be cut by the ultraviolet-rays cutting filter in deficiency inspection by the magnetic-particle inspection method, an inspector can easily confirm the results of the automatic deficiency inspection. Further, because a deficiency candidate is automatically indicated and displayed on the screen, miss-inspection hardly occurs. What is more, as the inspected image is saved, it is possible to display the image saved after inspection on the screen and check a deficiency again, thus improving the inspection reliability.

As a color video camera is used in the invention, automatic deficiency inspections of the magnetic-particle inspection and penetrant inspection can be executed by the same sensor probe, so that the usability is improved considerably.